

## PROCESS FOR PREPARING PHOSPHORODIAMIDITES

The present invention relates to an improved method for the production of phosphorodiamidites, phosphorodiamidites produced by way of such a method and the use of such phosphorodiamidites.

Production of phosphorodiamidites has become increasingly important in the biotechnology industry. Phosphorodiamidites are used as intermediates in the manufacture of novel anti-neoplastic agents.

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To be suitable for use in such industries phosphorodiamidites must be of high purity. Such phosphorodiamidites must also contain low levels of bis-(2-cyanoethyl) phosphorodiamidite (the 'diester').

15 This impurity is known to be a significant by product in the synthesis of 2-cyanoethyl tetraisopropylphosphorodiamidite, a commercially important intermediate in the synthesis of oligonucleotides.

As phosphorodiamidites are very air sensitive and thermally unstable, their purification is, at present, complex and expensive. Hitherto, known processes of extraction and purification of phosphorodiamidites often involve multi-stage synthetic procedures which demand the chemical isolation of intermediate materials and require extensive purification procedures prior to the isolation of high purity phosphorodiamidite products.

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The present invention aims to ameliorate the aforementioned disadvantages of phosphorodiamidite production.

30 Accordingly, the present invention provides a method of phosphorodiamidite production which method comprises the steps of

reacting a phosphorus trihalide with a dialkyl amine in a polar solvent to form an intermediate compound and subsequently reacting the intermediate compound with a hydroxyalkyl compound and a dialkyl amine, in the presence of a non-polar co-solvent.

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Following filtration to remove the solid by-product, the two solvents form separate layers. This is advantageous as the upper, non-polar solvent, layer contains the high-purity phosphorodiamidite product. The lower, polar solvent, layer contains impure product contaminated with diester and other unwanted by-products. The upper layer is then subjected to vacuum-stripping to remove the solvent, leaving the desired product with greater than 96% purity and containing less than 1% of the diester impurity. The yield of the product can further be increased by optionally rewashing the polar solvent layer with a further quantity of non-polar solvent, to give non-polar solvent solution containing pure product, from which can then be isolated high-purity phosphorodiamidite.

Advantageously, impure product contaminated with diester and other impurities which would otherwise be unsuitable for commercial use can be extracted and purified by use of the solvent purification procedure. Phosphorodiamidite products are preferentially soluble in the non-polar co-solvent whereas the diester and other unwanted polar by-products are insoluble and remain in the polar solvent layer.

Preferably, the phosphorus trihalide is phosphorus trichloride. Alternatively, the phosphorus trihalide is phosphorus tribromide.

The dialkyl amine is preferably diisopropylamine. Alternatively the dialkyl amine may be dimethylamine, diethylamine, di-n-propylamine, di-n-butylamine, di-isobutylamine or di-tert-butylamine.

The polar solvent is preferably a nitrile compound, in particular, acetonitrile. Alternatively the polar solvent may be propionitrile or benzonitrile.

- 5 The hydroxyalkyl compound is preferably hydroxypropionitrile. Alternatively the hydroxyalkyl compound may be methanol, tert-butyl alcohol or other suitable hydroxyalkyl compounds which are known to be suitable for the manufacture of phosphorodiamidites.
- 10 The alkane co-solvent is preferably heptane or hexane. Other suitable C<sub>5</sub> to C<sub>9</sub> aliphatic hydrocarbons include pentane. Suitable alicyclic hydrocarbons include, for example, cyclohexane.

The ratio of polar solvent to non-polar solvent is suitably around 1:1.

- 15 The method according to the invention provides a phosphorodiamidite compound according to Formula I:



- 20 wherein R is a C<sub>1</sub> to C<sub>4</sub> alkyl, hydroxyalkyl or oxyalkyl group; and n is a whole number of from 1 to 4.

The compound according to formula I is preferably 2-cyanoethyl tetraisopropyl phosphorodiamidite wherein R is isopropyl, and n = 2.

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The present invention also provides the use of a compound of formula I in the synthesis of oligonucleotides.

- The present invention will now be illustrated, merely by way of example,  
30 as follows:

**Example 1****Manufacture of 2-cyanoethyl tetraisopropyl phosphorodiamidite using hexane co-solvent**

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27.5g of phosphorus trichloride at ambient temperature was added to a stirred mixture of acetonitrile (200g) and diisopropylamine (121g) over 1 hour. 200g of hexane is then added followed by 14g of hydroxypropionitrile at ambient temperature over 30 minutes. The reaction mixture is then stirred for 1 hour and is then filtered to remove the solid by-product. The upper hexane layer of the filtered reaction mixture is separated and subjected to vacuum stripping to remove the hexane solvent. This leaves 20g of 2-cyanoethyl tetraisopropylphosphorodiamidite which has a purity of 96.9% when analysed by <sup>31</sup>P-NMR. The lower acetonitrile layer is stirred with a further 200g of hexane for 2 hours. The upper hexane layer from this re-extraction contains product of 98% purity when assayed by <sup>31</sup>P-NMR. Following vacuum stripping a further 11g of high purity 2-cyanoethyl tetraisopropylphosphorodiamidite is isolated.

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**Example 2****Manufacture of 2-cyanoethyl tetraisopropylphosphorodiamidite using heptane co-solvent**

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27.5g of phosphorus trichloride was added to a stirred mixture of 200g of acetonitrile and 121g of diisopropylamine at ambient temperature. 200g of heptane was then added to this mixture followed by 14.3g of hydroxypropionitrile at ambient temperature over 30 minutes. The reaction mixture was then stirred for an hour and was then filtered to remove the solid by-product. The upper heptane layer was then separated

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and subjected to vacuum stripping to remove the heptane solvent leaving 22g of 2-cyanoethyl tetraisopropylphosphorodiamidite which had a purity of 96.7% when assayed by  $^{31}\text{P}$ -NMR.

### 5 Example 3

#### Purification of low purity 2-cyanoethyl tetraisopropylphosphorodiamidite

- 10 60g of low purity 2-cyanoethyl tetraisopropylphosphorodiamidite (92% purity when assayed by  $^{31}\text{P}$ -NMR containing 1.3% diester) was added to a mixture of 200g acetonitrile and 200g of heptane after stirring for ten minutes the upper heptane layer was separated and the lower acetonitrile layer stirred with a further 200g of heptane for a further 10 minutes. The
- 15 second heptane fraction was then separated and the two heptane fraction subsequently combined and subjected to vacuum stripping to remove heptane solvent. 30g of 2-cyanoethyl tetraisopropylphosphorodiamidite was obtained at a purity of 98.3% when assayed by  $^{31}\text{P}$ -NMR. This extracted phosphorodiamidite compound contained less than 0.1% of the
- 20 diester impurity.